SECONDARY STRESSES IN 112 FOOT RAILROAD PONY TRUSS

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SECONDARY STRESSES IN 112 FOOT RAILROAD PONY TRUSS

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Preface.

The analysis of Secondary Stresses, although such stresses were recognised by engineers in their designs, has been considered a very laborious operation and until recently their computation was deemed unnecessary in most cases.

The purpose of this thesis is to present a systematic method for the solution and a convenient arrangement of the calculations, and also to show the importance of secondary stresses in trusses of relatively small proportions.

The authors have not attempted to introduce or apply any new theory. For the derivation of the formulae, the reader is referred to an excellent treatise on the subject by Johnson, Bryan, and Turneaure " Modern Framed Structures " - Part 2.

The authors have chosen what they believe to be a typical problem, and it is hoped that the present work will prove of benefit to those desirous of acquiring a working knowledge of the subject.

May 25, 1921. Chicago, Ill.

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Primary and Secondary Stresses Defined.

In the analysis of stresses in a truss it is usually assumed :

(1) The joints lie in the gravity axes of the members.

(2) All external loads and weights of members are applied at the joints only.

(3) All members are free to turn at the joints.

(4) All members are straight, and remain straight after the loads are applied.

The stresses resulting from a determination based on these assumptions are called " Primary " or direct stresses.

That these assumptions are not realized in practice is easily apparent.

(1) The joints are often eccentric.

(2) The weights of the individual members are carried to the joints by the members acting as beams.

(3) The members are not free to turn at the joints. This must be true in riveted connections, and is true to a considerable extent even in pin connections, because there is always friction between the pin and the member.

(4) The members themselves are not straight and do not remain straight after the loads are applied. Since the members are rigid at the joints, a change in relative position of the joints due to the primary stresses will introduce a single or double bending in the member.

The stresses resulting from this bending due to the rigidity of the joint connections and the other factors mentioned are called " Secondary Stresses."

It has been found that the most important of the secondary stresses are the bending stresses, and consequently an analysis of the other secondary stresses has been omitted.

Formulae.

Calculation of the changes of angle in any triangle in terms of the changes in the lengths of the members.

$$da = \frac{s_3 - s_2}{E} \cot B + \frac{s_3 - s_1}{E} \cot Y \quad (1)$$

$$dB = \frac{s_1 - s_3}{E} \cot Y + \frac{s_1 - s_2}{E} \cot a \quad (2)$$

$$dY = \frac{s_2 - s_1}{E} \cot a + \frac{s_2 - s_3}{E} \cot B \quad (3)$$

The deflection angles of a beam subjected to given moments applied at the two ends.

$$M_1 = \frac{2EI}{l} (2T_1 + T_2) \quad (4)$$

$$M_2 = \frac{2EI}{l} (2T_2 + T_1) \quad (5)$$

Values of the deflection angles T in terms of the changes of angle da, etc.

$$T_{nm} = T_{n1} + \sum_1^m da \quad (6)$$

The moments at any joint in terms of the deflection angles T.

(See formula 17, page 432- Johnson, Bryan, Turneaure,- Part 11.)

The moment and fibre stress in terms of T.

$$M_{nm} = 2\,EK_{nm}\,(\,2T_{nm} + T_{mn}\,) \qquad (8)$$

$$f_{nm} = \frac{2Ec}{l}\,(\,2T_{nm} + T_{mn}\,) \qquad (9)$$

In these equations M_{nm} and f_{nm} are respectively the bending moments and fibre stress at joint n in member nm, and c = distance of fibre from neutral axis.

Explanation of Tables.

Table A. Data necessary for the determination of constants.

Table B. Calculation of changes of angle, arranged by triangles.

Table C. Calculation of ΣdL and $K\Sigma dL$ at the several joints.

Table D. Formulation of equations using Table C.

Table E. Solution of equations.

Table F. Determination of fibre stress for each member at each joint.

Table G. Values of secondary stresses in terms of percentage of maximum primary stresses.

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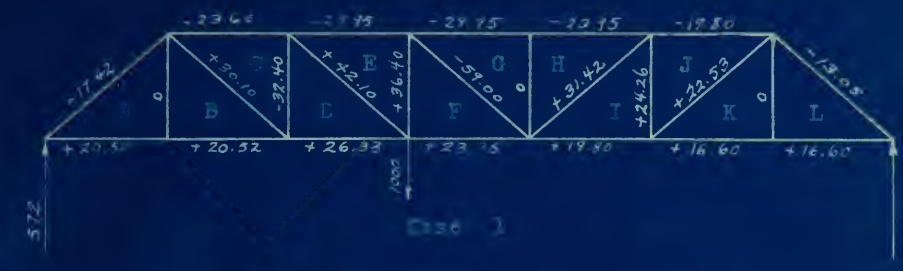
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+31.42
+24.26
+22.53
-13.05
A
B
C
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H
I
J
K
L
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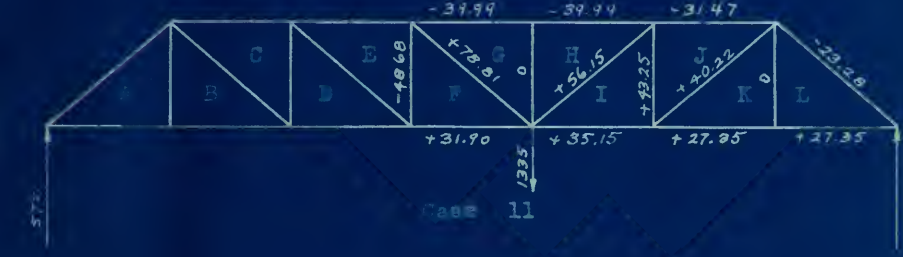
572
Case I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D
E
F
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L
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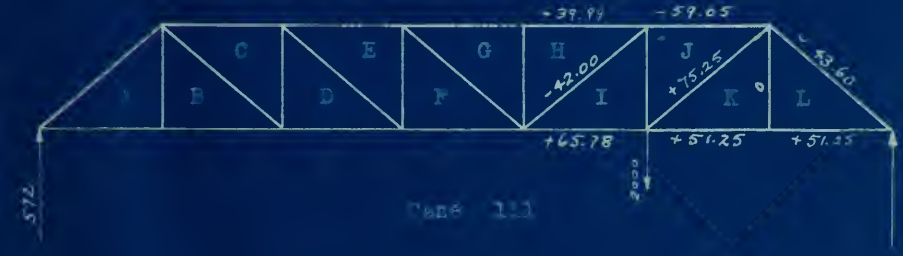
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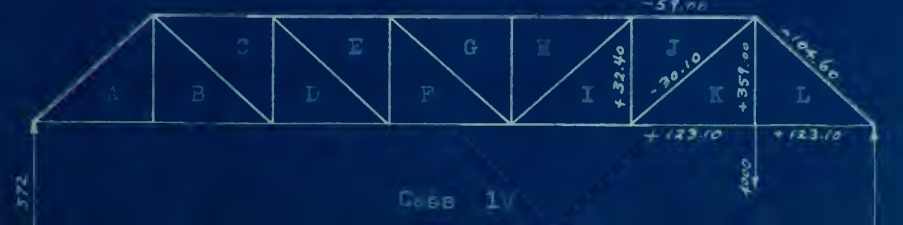
+51.35
2000
572
Case III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+359.00
A
B
C
D
E
F
G
H
I
J
K
L
+123.10
+123.10
4000
572
Case IV

TABLE

Member	Section area	Length inches	I	c inches	$r = \sqrt{\frac{I}{A}}$	$\frac{l}{r}$	Section
1-2	37.16	192	3988	11.12	10.01	.058	
2-4	37.16	192	3988	11.12	10.01	.058	
4-6	57.88	192	3500	11.12	18.22	.058	
6-9	71.66	192	3795	11.12	19.76	.058	
1-3	54.62	240	3343	9.38	13.93	.039	See Pony truss
3-5	64.56	192	4318	10.45	22.50	.054	
5-7	76.31	192	4458	10.45	23.20	.054	
7-8	76.31	192	4458	10.45	23.20	.054	
3-2	11.15	144	401	6.75	2.78	.047	
3-4	31.64	240	1144	6.75	4.77	.028	
5-4	17.64	144	323	6.00	2.24	.042	
5-6	22.66	240	660	6.75	2.75	.028	
7-6	11.76	144	157	5.00	1.09	.035	
7-9	12.09	240	423	6.75	1.76	.028	

TABLE 8-1

Tri-Angle	Angle	(1.3333) Factor of cot a	(.7500) Factor of cot	dL
A	1	----------	0 17.42	13.06
	2	-17.42 -50.82	-17.42 - 0	-63.71
	3	50.82 17.42	----------	50.65
B	2	30.10 -20.52	30.10 - 0	38.39
	3	20.52 -30.10	----------	-12.79
	4	----------	0 -30.10	-22.60
C	3	----------	-32.40 -30.10	-46.83
	4	-23.60 -30.10	----------	-71.60
	5	30.10 23.60	30.10 32.40	118.43
D	4	42.10 -20.33	42.10 32.40	76.90
	5	20.33 -42.10	----------	-21.05
	6	----------	-32.40 -42.10	-55.85
E	5	----------	36.40 -42.10	- 5.70
	6	-29.95 -42.10	----------	-96.00
	7	42.10 29.95	42.10 -36.40	101.70
F	6	-59.00 -23.95	-59.00 -36.40	-178.30
	7	23.95 59.00	----------	82.95
	8	----------	36.40 59.00	96.40
G	7	----------	0 59.00	59.00
	8	-59.00 29.95	-59.00 - 0	-88.05
	9	-29.95 59.00	----------	29.05
H	8	31.42 23.95	31.42 - 0	25.79
	9	-23.95 -31.42	----------	-54.37
	10	----------	0 -31.42	-31.42
I	9	----------	24.26 -31.42	- 5.37
	10	19.80 -31.42	----------	-15.50
	11	31.42 -19.80	31.42 -24.26	20.87
J	10	22.53 19.80	22.53 -24.26	55.20
	11	-19.80 -23.53	----------	-56.50
	12	----------	24.26 -22.53	1.30
K	11	----------	0 -22.53	-16.90
	12	16.60 -22.53	----------	- 7.91
	13	22.53 -16.60	22.53 - 0	24.81
L	12	16.60 15.05	----------	39.56
	13	-15.05 -16.60	-15.05 - 0	-49.35
	14	----------	0 15.05	9.80

TABLE B-2

Tri-angle	Angle	Factor of cot A (1.3333)	Factor of cot B (.7500)	dL
E	5	----------	-56.25 -42.19	-68.18
	6	-69.95 -52.46	----------	-96.00
	7	42.19 52.95	52.46 56.25	164.18
F	6	78.81 -31.90	78.81 48.68	158.25
	7	31.90 -78.81	----------	-82.50
	9	----------	-48.68 -78.81	-95.75
G	7	----------	0 -78.81	-59.15
	8	78.81 39.99	78.81 - 0	217.55
	9	-39.99 -78.81	----------	-158.40
H	8	56.15 39.99	56.15 - 0	170.30
	9	-39.99 -56.15	----------	-128.20
	10	----------	0 -56.15	- 42.10
I	9	----------	43.25 -56.15	- 9.67
	10	35.15 -56.15	----------	- 28.00
	11	56.15 -35.15	56.15 -43.25	37.67
J	10	40.22 31.47	40.22 -10.15	83.33
	11	-31.47 -40.22	----------	-95.60
	12	----------	-10.15 -40.22	2.27
K	11	----------	0 -40.22	-30.10
	12	27.35 -40.22	----------	-17.15
	13	40.22 -27.35	40.22 - 0	47.31
L	12	7.35 42.29	----------	67.43
	13	-42.29 -29.56	-29.56 - 0	-68.09
	14	----------	0 29.56	17.46

TABLE 3-3

Tri-angle	Angle	Factor of cot	Factor of cot B	dI
H	8 9 10	-40.00 52.00 -52.00 40.00 ----------	-40.00 - 0 ---------- 0 40.00	- 4.13 4.68 81.60
I	9 10 11	---------- 52.78 40.00 -52.00 -40.78	40.40 40.00 ---------- -40.00 -40.40	20.61 143.80 -1[illegible].61
J	10 11 12	[illegible].40 [illegible].00 -40.00 -78.85 ----------	78.40 - [illegible].40 ---------- [illegible].40 -78.[illegible]	811.19 -1[illegible].00 - [illegible].13
K	11 12 13	---------- 81.85 -78.85 78.[illegible] -81.[illegible]	0 -78.85 ---------- 78.85 - 0	- [illegible].49 - [illegible].00 80.49
L	12 13 14	51.[illegible] 40.00 -41.00 -[illegible].[illegible] ----------	---------- -40.00 - 0 0 40.00	[illegible].00 -1[illegible].[illegible] [illegible].65

TABLE 3-4

Tri-angle	Angle	Factor of cot B	Factor of cot B	dL
J	10 11 12	-[illegible].10 [illegible].00 -[illegible].00 [illegible].10 ----------	-[illegible].10 -[illegible].40 ---------- [illegible].40 [illegible].10	- [illegible].00 - [illegible].[illegible] [illegible].[illegible]
K	11 12 13	---------- [illegible].10 [illegible].10 -[illegible].10-[illegible].[illegible]	[illegible].00 [illegible].00 ---------- -[illegible].10-[illegible].00	[illegible].00 [illegible].[illegible] -[illegible].[illegible]
L	12 13 14	[illegible].10 104.00 -[illegible].00-[illegible].10 ----------	---------- -[illegible].00-[illegible].00 [illegible].00 [illegible].00	[illegible].00 -[illegible].[illegible] [illegible].00

Calculation of ΣdL and $R\,\Sigma dL$

Case 1

JOint	Member	K	Angle	dL	ΣdL	$R\,\Sigma dL$
1	1-3 1-2	16.94 12.83 29.48	------	------	------	------
			3-1-2	13.06	13.06	202.55 202.55
2	2-1 2-3 2-4	16.55 4.78 12.55 33.88	------	------	------	------
			1-2-3	-23.71	-23.71	- 177.00
			3-2-4	35.39	-23.32	- 440.10 - 617.10
3	3-5 3-4 3-2 3-1	23.50 4.77 2.78 12.83 43.88	------	------	------	------
			5-3-4	-46.83	-46.83	- 223.50
			4-3-2	-12.78	-59.62	- 165.80
			2-3-1	36.05	- 3.57	- 169.00
12	12-13 12-11 12-10	2.78 4.77 28.50 36.05	------	------	------	------
			14-12-13	23.85	20.28	139.00
			13-12-11	- 7.91	31.65	180.90
			11-12-10	1.30	32.95	741.60 1062.50
13	13-11 13-12 13-14	16.55 2.78 16.55 35.88	------	------	------	------
			11-13-12	24.81	24.81	89.00
			12-13-14	- 49.36	- 24.55	- 381.50 - 312.50
14	14-12 14-13	13.93 15.55 29.48	13-14-12 ------	9.80 ------	9.80 ------	136.70 ------ 136.70

Calculation of ΣdL and KΣdL

Case 1

Joint	Member	K	Angle	dL	ΣdL	K ΣdL
1	1-3	16.93	------	-------	--------	---------
	1-2	12.55	3-1-2	13.06	13.06	202.55
		29.48				202.55
2	2-1	12.55	------	-------	--------	---------
	2-3	2.79	1-2-3	-63.71	-63.71	- 177.80
	2-4	18.55	3-2-4	35.39	-28.32	- 440.10
		33.89				- 810.10
3	3-5	27.50	------	-------	--------	---------
	3-4	4.77	5-3-4	-46.83	-46.83	- 233.80
	3-2	2.78	4-3-2	-12.79	-59.62	- 165.80
	3-1	16.93	2-3-1	50.65	- 8.97	- 185.00
		43.98				
4	4-2	12.55	------	-------	--------	---------
	4-3	4.77	2-4-3	-22.60	-22.60	- 107.86
	4-5	2.84	3-4-5	-71.60	-94.20	- 210.90
	4-6	16.22	5-4-6	76.90	-17.30	- 318.30
		40.78				- 634.06
5	5-7	23.20	------	-------	--------	---------
	5-6	2.78	7-5-6	- 5.70	- 5.70	- 15.68
	5-4	2.84	6-5-4	-31.05	-26.75	- 89.90
	5-3	22.50	4-5-3	113.43	91.68	2063.00
		50.32				1988.46
6	6-4	16.22	------	-------	--------	---------
	6-5	2.75	8-6-5	-22.85	-55.85	- 163.80
	6-7	1.09	5-6-7	-96.00	-151.85	- 165.40
	6-9	19.76	7-6-9	-179.30	-330.10	-6646.00
		41.32				-6343.90
7	7-8	23.20	------	-------	--------	---------
	7-9	1.76	8-7-9	59.00	59.00	103.80
	7-6	1.09	9-7-6	82.95	141.95	154.70
	7-5	23.20	6-7-5	101.70	243.65	5650.00
		49.25				5908.50
8	8-10	23.20	------	-------	--------	---------
	8-9	1.09	10-8-9	84.79	84.79	92.30
	8-7	23.20	9-8-7	- 89.05	- 2.26	- 52.45
		47.99				41.05
9	9-8	19.76	------	-------	--------	---------
	9-7	1.76	8-9-7	95.40	95.40	167.80
	9-8	1.09	7-9-8	29.05	124.45	135.70
	9-10	2.75	8-9-10	- 54.37	70.08	192.60
	9-11	18.22	10-9-11	- 5.37	64.71	1175.00
10	10-12	22.50	------	-------	--------	---------
	10-11	2.84	12-10-11	48.20	55.20	156.50
	10-9	2.75	11-10-9	+ 15.50	39.70	109.10
	10-8	23.20	9-10-8	+ 31.42	8.28	192.00
		50.69				454.60
11	11-9	18.22	------	-------	--------	---------
	11-10	2.84	9-11-10	20.87	20.87	46.80
	11-12	4.77	12-11-12	- 46.80	- 35.63	- 170.00
	11-13	15.55	12-11-13	+ 16.90	- 52.53	- 816.80
12	12-14	13.93	------	-------	--------	---------
	12-13	2.78	14-12-13	39.56	39.56	109.90
	12-11	4.77	13-12-11	- 7.91	31.65	150.90
	12-10	22.50	11-12-10	1.30	32.95	741.50
		43.98				1002.30
13	13-11	15.55	------	-------	--------	---------
	13-12	2.78	11-13-12	24.81	24.81	69.00
	13-14	15.55	12-13-14	- 48.36	- 24.55	- 381.80
		33.88				- 312.80
14	14-12	13.93	13-14-12	9.80	9.80	136.70
	14-13	15.55	------	-------	--------	---------
		29.48				136.70

TABLE C-3

Calculation of $\Sigma d\theta$ and $\Sigma\Sigma d\theta$

Case 11

Joint	Member	L	Angle	$d\theta$	$\Sigma d\theta$	$\Sigma\Sigma d\theta$
	8-7	23.80	--------	--------	--------	----------
12	12-11	4.77	10-12-11	- 27.1[illegible]	- 68.18	- 187.20
	12-10	23.50	11-12-10	2.27	52.55	1182.50
		43.98				1869.30
13	13-11	12.65	--------	--------	--------	----------
	13-12	9.78	11-13-12	47.31	47.31	181.70
	13-14	12.35	12-13-14	- 68.09	- 20.78	- 323.20
		34.88				- 191.70
14	14-13	15.55	--------	--------	--------	----------
	14-12	13.93	13-14-12	32.65	32.65	423.00
		29.48				455.00

TABLE C-2

Calculation of ΣdL and KΣdL

Case 11

Joint	Member	K	Angle	dL	ΣdL	KΣdL
5	5-7	23.80	-------	-------	-------	----------
	5-6	2.78	7-5-6	- 68.18	- 68.18	- 187.30
	5-4	2.24	6-5-4	- 21.05	- 89.23	- 190.30
	5-3	22.80	4-5-3	118.43	29.20	70[illegible].50
		50.69				318.40
6	6-4	18.22	-------	-------	-------	----------
	6-5	2.75	4-6-5	- 55.85	- 55.85	- 1[illegible].53
	6-7	1.09	5-6-7	- 80.00	- 135.85	- 1[illegible].50
	6-9	19.76	7-6-9-	1[illegible].25	[illegible].40	126.40
		41.82				- 190.55
7	7-8	23.80	-------	-------	-------	----------
	7-6	1.76	8-7-6	- 72.15	- 80.15	- 104.00
	7-8	1.09	9-7-8	- 98.50	- 181.65	- 153.62
	7-5	23.80	6-7-5	104.18	48.83	58[illegible].50
		49.85				749.33
8	8-10	32.80	-------	-------	-------	----------
	8-9	1.09	10-8-9	170.20	170.20	185.85
	8-7	23.20	9-8-7	217.65	387.85	9000.00
		47.49				9185.85
9	9-6	19.76	-------	-------	-------	----------
	9-7	1.76	6-9-7	- 95.75	- 95.75	- 168.45
	9-8	1.09	7-9-8	-158.40	- 254.15	- 277.00
	9-10	2.75	8-9-10	-128.20	- 382.35	- 1052.00
	9-11	18.22	10-9-11	- 9.87	- 392.02	- 7150.00
		43.58				- 8647.75
10	10-12	28.80	-------	-------	-------	----------
	10-11	2.24	12-10-11	90.33	90.33	202.50
	10-9	2.75	11-10-9	- 25.00	68.33	179.60
	10-8	23.20	9-10-8	- 42.10	23.23	539.50
		50.69				927.80
11	11-9	18.22	-------	-------	-------	----------
	11-10	2.24	9-11-10	37.87	37.87	84.48
	11-12	4.77	10-11-12	- 20.60	- 57.95	- 276.20
	11-13	15.55	12-11-13	- 30.16	- 88.00	- 1368.00
		40.78				- 1560.72
12	12-14	15.93	-------	-------	-------	----------
	12-13	2.78	14-12-13	67.43	67.43	187.30
	12-11	4.77	13-12-11	- 17.15	50.28	239.80
	12-10	22.30	11-12-10	2.27	52.55	1182.80
		45.98				1609.90
13	13-11	15.55	-------	-------	-------	----------
	13-12	2.78	11-13-12	47.31	47.31	131.00
	13-14	15.55	12-13-14	- 68.09	- 20.78	- 322.20
		33.88				- 191.70
14	14-13	15.55	-------	-------	-------	----------
	14-12	13.93	13-14-12	32.65	32.65	455.00
		29.48				455.00

TABLE C-3

Calculation of ΣdL and $K\Sigma dL$

Case III

Joint	Member	K	Angle	δl	ΣdL	$K\Sigma dL$
8	8-10	23.20	--------	--------	--------	--------
	8-9	1.09	10-8-9	- 34.18	- 34.18	- 37.23
	8-7	23.20	9-8-7	217.55	183.37	4258.00
		47.49				4220.77
9	9-8	10.76	--------	--------	--------	--------
	9-7	1.76	8-9-7	- 98.75	- 98.75	- 185.50
	9-8	1.09	7-9-8	-158.40	-256.15	- 277.00
	9-10	8.75	8-9-10	5.68	-251.47	- 685.00
	9-11	19.22	10-9-11	56.91	-195.66	-3563.00
		43.58				-4690.50
	10-12	[illegible]				455.00

TABLE C-3

Calculation of ΣdL and KΣdL

Case 111

Joint	Member	K	Angle	dL	ΣdL	KΣdL
8	8-10	23.20	--------	--------	--------	--------
	8-9	1.09	10-8-9	- 34.18	- 34.18	- 37.23
	8-7	23.20	9-8-7	217.55	183.37	4253.00
		47.49				4290.77
9	9-8	19.76	--------	--------	--------	--------
	9-7	1.76	8-9-7	- 95.75	- 95.75	- 169.50
	9-8	1.09	7-9-8	-158.40	-254.15	- 277.00
	9-10	2.75	8-9-10	2.68	-251.47	- 284.00
	9-11	18.22	10-9-11	55.81	-195.66	-3565.00
		43.58				-4290.50
10	10-12	22.50	--------	--------	--------	--------
	10-11	2.24	12-10-11	311.13	311.13	472.80
	10-9	2.75	11-10-9	143.80	384.93	576.80
	10-8	23.20	9-10-8	31.80	396.43	6071.00
		50.69				10433.60
11	11-9	18.22	--------	--------	--------	--------
	11-10	2.24	9-11-10	-199.61	-199.61	- 447.50
	11-12	4.77	10-11-12	-179.00	-378.61	-1805.00
	11-13	15.55	12-11-13	- 59.49	-438.10	-6796.00
		40.78				-9049.50
12	12-14	12.23	--------	--------	--------	--------
	12-13	2.79	14-12-13	126.10	126.60	282.00
	12-11	4.77	13-12-11	- 37.00	94.60	451.80
	12-10	23.20	11-12-10	- 30.19	62.41	1447.00
		42.99				2181.80
13	13-11	15.55	--------	--------	--------	--------
	13-12	2.79	11-13-12	88.49	88.49	246.00
	13-14	15.55	12-13-14	-158.25	- 70.76	-1099.00
		33.89				- 853.00
14	14-13	15.55	--------	--------	--------	--------
	14-12	13.93	13-14-12	32.65	32.65	455.00
		29.48				455.00

TABLE C-4

Calculation of ΣdL and $K\Sigma dL$

Case IV

Joint	Member	K	Angle	dL	ΣdL	$K\Sigma dL$
10	10-12	25.50	-------	-------	-------	----------
	10-11	8.24	12-10-11	- 8.30	- 8.30	- 10.62
	10-9	8.78	11-10-9	140.80	132.50	373.00
	10-5	22.10	9-10-5	33.80	166.30	2870.00
		50.62				4234.41
11	11-9	18.82	-------	-------	-------	----------
	11-10	2.24	9-11-10	-199.61	- 199.61	- 447.60
	11-12	4.77	10-11-12	- 33.52	- 233.13	- 1125.00
	11-13	15.55	10-11-13	292.00	58.87	909.10
		40.78				- 737.10
12	12-14	13.98	-------	-------	-------	----------
	12-13	9.70	14-12-13	308.50	308.50	844.10
	12-11	4.77	13-12-11	204.50	506.00	2400.00
	12-10	22.00	11-12-10	48.82	554.82	12440.00
		42.98				15748.20
13	13-11	19.85	-------	-------	-------	----------
	13-12	9.70	11-13-12	-496.50	- 496.50	- 1380.00
	13-14	15.88	12-13-14	-651.40	-1147.90	-17855.00
		35.43				-19235.00
14	14-13	13.88	-------	-------	-------	----------
	14-12	13.60	13-14-12	347.90	347.90	4848.00
		27.48				4848.00

Tabulation of Equations

No. of Joint	First Member of Equation	Absolute Terms			
		Case 1	Case 11	Case 111	Case
1	$58.96T_1+15.55T_2+13.93T_3$	280.10			
2	$15.55T_1+87.76T_2+2.78T_3+13.55T_4$	- 1197.45			
3	$13.93T_1+2.78T_2+37.96T_3+4.77T_4+22.50T_5$	167.55			
4	$15.55T_2+4.77T_3+81.56T_4+2.24T_5+18.22T_6$	- 2049.55			
5	$22.50T_3+2.24T_4+101.96T_5+2.75T_6+23.20T_7$	- 9258.44	-1352.90		
6	$18.22T_4+2.75T_5+83.64T_6+1.09T_7+19.76T_9$	13864.08	1020.12		
7	$23.20T_5+1.09T_6+98.50T_7+23.20T_8+1.76T_9$	-11766.65	7833.99		

TABLE 3

Tabulation of Equations

No. of Joint	First member of Equation	Absolute Terms			
		Case I	Case II	Case III	Case IV
1	$58.96T_1+15.55T_2+13.93T_3$	280.10			
2	$15.55T_1+67.76T_2+2.78T_3+15.55T_4$	- 1197.45			
3	$13.93T_1+2.78T_2+87.96T_3+4.77T_4+22.50T_5$	167.55			
4	$15.55T_2+4.77T_3+81.56T_4+2.24T_5+18.22T_6$	- 2048.55			
5	$22.50T_3+2.24T_4+101.38T_5+2.75T_6+23.20T_7$	- 9258.44	-1352.90		
6	$18.22T_4+2.75T_5+83.64T_6+1.09T_7+19.76T_9$	13864.08	1020.12		
7	$23.20T_5+1.09T_6+96.50T_7+23.20T_8+1.76T_9$	-11766.65	7833.99		
8	$23.20T_7+94.96T_8+1.09T_9+23.20T_{10}$	- 409.80	18633.90	-17139.5	
9	$19.76T_6+1.76T_7+1.09T_8+87.18T_9+2.75T_{10}+18.22T_{11}$	2871.00	16907.70	8420.0	
10	$23.20T_8+2.75T_9+101.38T_{10}+2.24T_{11}+22.50T_{12}$	- 1830.10	-2070.58	-21126.7	-13769.
11	$18.22T_9+2.24T_{10}+81.56T_{11}+4.77T_{12}+15.55T_{13}$	1885.80	9823.14	20693.4	2654.
12	$22.50T_{10}+4.77T_{11}+87.96T_{12}+2.78T_{13}+13.93T_{14}$	- 2040.30	-3317.30	- 3321.8	-33825.
13	$15.55T_{11}+2.78T_{12}+67.76T_{13}+15.55T_{14}$	1331.60	1565.10	8129.0	36690
14	$13.93T_{12}+15.55T_{13}+58.96T_{14}$	108.10	- 163.60	189.0	8159

m			1	121.00	4.04	46.88		- 817.00	24460.00	12000.100	13000.00
n'			1	.01	.26			23.40	136.80	- 814.00	- 814.00
10			1	.12	4.37	.10	.97	- 78.90	- 89.30	- 910.50	- 854.00
				-120.9	-3.78	-26.85		540.40	-24263.30	-12014.0	-12014.0

1	5.06	- 4.74	3.99	-62.16	-57.0	174.9	-114.7	28.9	-6.8	-21.0	24.1	-20.0	14.3	2.6
11	8.92	-16.8	1.03	-13.0	-16.2	-38.2	32.9	202.1	194.3	-64.4	81.8	-26.1	4.9	2.1
111	8.25	-15.1	2.03	-19.9	-37.2	- 6.5	127.1	-168.3	84.9	177.2	232.5	-5.0	73.7	-16.0
1V	8.57	-16.1	1.77	-15.8	-36.4	-24.0	121.9	151.7	125.4	243.9	-75.8	397.4	587.0	86.0

TABLE 8

Solution of Equations

No. of Eq.	T_L	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	Absolute Terms Case 1	Case 11	-----
1'	1	.25	.24							4.750		
2'	1	4.56	.18	1.00						-77.000		
3'	1	.20	5.61	.34	1.61					12.00		
a		4.10	- .06	1.00						- 81.75		
b		- .06	6.07	.34	1.61					7.25		
a'		1	- .01	.24						- 19.95		
b'		- 1	95.00	6.26	2.48					11.16		
4'		1	.31	5.25	.14	1.17				-132.00		
c			94.99	5.31	2.48					- 8.79		
d			.32	5.01	.14	1.17				-112.05		
c'			1	.09	.05					- .09	- .09	
d'			1	18.69	.45	3.66				-349.00	-349.00	
5'			1	.10	4.92	.12	1.03			-412.00	- 55.70	
e				18.53	.42	3.66				-348.91	-348.91	
f				.04	4.49	.12	1.03			-411.91	- 55.61	
e'				1	.03	.24				- 22.45	- 22.45	
f'				1	4.77	.13	1.09			-437.00	- 59.15	
6'				1	.15	4.58	.06		1.08	760.00	56.00	
g					4.75	- .11	1.09			-414.55	- 36.70	
h					.12	4.34	.06		1.08	737.56	33.85	
g'					1	- .02	.23			- 87.40	- 7.74	
h'					1	35.08	.44		8.75	5960.00	270.89	
7'					1	.05	4.25	1.00	.08	-507.50	337.80	
i						35.10	.21		8.75	6037.40	278.54	
j						.07	4.02	1.00	.08	-480.10	345.54	

TABLE 8 (cont.)

Note change in column headings

No. of Eq.	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	Absolute Terms Case 1	Case 11	Case 111	Case 1V
i'	1	.01		.25				172.00	7.92	7.92	
j'	1	58.20	14.50	1.10				-6090.00	5015.00	5015.00	
9'	1	.09	.06	4.42	.14	.92		145.30	856.00	426.80	
k		58.19	14.50	.85				-6262.00	5007.08	5007.08	
l		.08	.06	4.17	.14	.92		- 20.70	848.08	418.88	
k'		1	.25	.02				- 107.60	86.00	86.00	
l'		1	.66	50.19	1.68	11.13		- [illegible].00	1023.00	5052.00	
8'		1	4.10	.05	1.00			- 17.68	804.00	- 738.50	
m			.41	50.17	1.68	11.13		- 214.40	10134.00	4966.00	
n			3.85	.03	1.00			89.92	718.00	- 824.50	
m'			1	121.00	4.04	26.85		- 517.00	24150.00	12006.00	12000.00
n'			1	.01	.26			23.40	186.80	- 814.00	- 814.00
10'			1	.12	4.37	.10	.97	- 78.90	- 89.30	- 816.50	- 866.00
o				-120.9	-3.78	-26.85		540.40	-24263.70	-11914.0	-11914.0
p				-120.8	.33	-26.75	.97	438.10	-24339.30	-12910.5	-12880.0

TABLE E (cont.)

Note change in column headings

No. of Eq.	T_9	T_{10}	T_{11}	T_{12}	T_{13}	T_{14}	Absolute Terms Case I	Case II	Case III	Case IV
o'	-1	- .03	- .22				4.47	- 200.50	- 101.00	- 101.00
p'	-1	.00	- .22	.01			3.62	- 202.80	- 104.80	- 104.80
11'	1	.12	4.48	.26	.85		103 .40	339.70	1138.00	148.50
q		.03	.00	.01			- .85	- 2.30	- 5.80	- 5.80
r		.09	4.26	.26	.85		107.87	339.20	1034.00	44.50
q'		1	.03	.24			- 24.92	- 87.70	- 170.80	- 183.00
r'		1	46.25	2.85	9.28		1173.00	3690.00	11250.00	484.00
12'		1	.21	3.01	.12	.62	- 90.65	- 147.80	- 147.60	- 1505.00
s			46.92	2.62	9.28		1197.92	3757.70	11420.50	657.00
t			.18	3.68	.12	.62	- 65.73	- 79.80	22.90	- 1352.00
s'			1	.06	.20		25.93	81.30	247.00	13.77
t'			1	20.70	.70	3.48	- 309.20	- 447.00	128.80	- 7600.00
13'			1	.18	4.36	1.00	83.80	100.70	537.00	3380.00
u				20.64	.50	3.48	- 395.13	- 526.30	- 118.20	- 7613.77
v				.12	4.16	1.00	59.87	19.40	290.00	2346.23
u'				1	.02	.17	- 13.15	- 25.30	- 8.75	- 569.80
v'				1	33.80	8.13	437.00	158.00	2360.00	13080.00
14'				1	1.12	4.23	7.76	- 11.74	13.57	884.50
w					33.78	7.96	506.15	183.60	2365.73	19449.50
x					1.09	4.06	26.91	13.86	19.30	958.00
w'					1	.24	14.98	5.44	70.05	576.80
x'					1	3.72	24.66	12.70	17.70	877.00
y						3.48	9.68	7.27	- 52.35	300.20
y'						1	2.78	2.08	- 15.04	86.05

VALUES OF T

Case	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	T_{13}	T_{14}
I	5.06	- 4.74	3.99	+62.16	-57.0	174.9	-114.7	28.9	-3.8	-21.0	84.1	-20.0	14.3	2.9
II	8.92	+16.8	1.05	-13.0	-16.2	-38.2	32.9	202.1	194.3	-64.4	81.8	-26.1	4.9	2.1
III	8.85	+16.1	2.03	-19.9	-37.2	- 6.5	127.1	+168.3	84.9	-177.8	232.5	-5.0	73.7	-15.0
IV	8.57	+16.1	1.77	-15.8	-36.4	-24.0	121.9	-151.7	125.4	243.9	-75.8	397.4	87.0	85.0

Point	Member	$\frac{c}{l}$	Case 1 1000 # at point 6		
			T	$2T_{nn} + T_{nn}$	f
1	1-2	.010	2.00	4.14	0.10
	1-6	.048	8.00	8.14	- 0.87
	1-7	.040	12.14	21.10	0.08
2	2-1	.008	- 1.71	.00	1.00
	2-3	.047	- 8.45	- 18.47	- 1.10
11	11-7	.058	14.00	134.11	13.02
	11-10	.042	44.00	134.09	10.36
	11-12	.058	- 11.88	- 11.45	- 0.04
	11-16	.058	- 8.32	- 42.87	- 8.35
12	12-11	.008	- 30.00	- 27.42	- 2.14
	12-13	.047	14.00	79.10	7.04
	12-11	.008	11.88	11.75	0.01
	12-10	.058	14.32	8.29	- 0.87
13	13-11	.008	14.00	0.21	.01
	13-12	.047	8.00	9.24	0.12
	13-14	.058	- 10.32	- 10.0	- 0.03
14	14-10	.008	1.71	- 4.56	- 0.34
	14-13	.008	10.68	2.16	0.10
	14-15	.048	1.00	2.10	- 0.09

TABLE E

Solution of Equations

No. of Eq.	T_L	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	Absolute Terms Case 1	Case 11	-----
1'	1	.25	.24							4.750		
2'	1	4.35	.13	1.00						-77.000		
3'	1	.20	6.21	.34	1.61					12.09		
a		4.10	- .05	1.00						- 81.75		
b		- .06	4.07	.34	1.61					7.25		
a'		1	- .01	.24						- 13.95		
b'		- 1	95.00	5.26	8.45					11.15		
4'		1	.31	5.25	.14	1.17				-132.00		
c			94.99	5.51	2.48					- 9.79		
d			.32	5.01	.14	1.17				-112.05		
c'			1	.06	.03					- .09	- .09	
d'			1	15.69	.45	3.66				-349.00	-349.00	
5'			1	.10	4.52	.12	1.03			-412.00	- 55.70	
e				15.53	.42	3.66				-348.91	-348.91	
f				.04	4.49	.12	1.03			-411.91	- 55.61	
e'				1	.03	.24				- 22.45	- 22.45	
f'				1	4.77	.13	1.09			-437.00	- 59.15	
6'				1	.13	4.58	.06		1.08	760.00	56.00	
g					4.75	- .11	1.09			-414.55	- 36.70	
h					.12	4.34	.06		1.08	737.56	33.55	
g'					1	- .02	.23			- 87.40	- 7.74	
h'					1	35.08	.44		8.75	6960.00	270.89	
7'					1	.05	4.25	1.00	.08	-507.30	337.80	
i						35.10	.21		8.75	6057.40	278.54	
j						.07	4.02	1.00	.08	-420.10	345.54	

TABLE E (cont.)

Note change in column headings

No. of Eq.	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	Absolute Terms Case 1	Case 11	Case 111	Case 1V
i'	1	.01		.25				172.00	7.92	7.92	
j'	1	58.20	14.50	1.10				-6090.00	5015.00	5015.00	
9'	1	.09	.06	4.42	.14	.92		145.50	856.00	426.80	
k		58.19	14.50	.85				-6262.00	5007.08	5007.08	
l		.08	.06	4.17	.14	.92		- 26.70	848.08	418.88	
k'		1	.25	.02				- 107.60	86.00	86.00	
l'		1	.66	50.19	1.68	11.13		- 322.00	1025.00	5052.00	
8'		1	4.10	.05	1.00			- 17.68	804.00	- 738.50	
m			.41	50.17	1.68	11.13		- 214.40	10134.00	4966.00	
n			3.35	.03	1.00			89.92	718.00	- 824.50	
m'			1	121.00	4.04	26.85		- 517.00	24150.00	12000.00	12000.00
n'			1	.01	.26			23.40	186.80	- 914.00	- 914.00
10'			1	.12	4.37	.10	.97	- 78.90	- 89.30	- 910.50	- 868.00
o				-120.9	-3.78	-26.85		540.40	-24263.20	-12014.0	-12814.0
p				-120.8	.33	-26.75	.97	438.10	-24539.30	-12910.5	-12882.0

TABLE E (cont.)

Note change in column headings

No. of Eq.	T_9	T_{10}	T_{11}	T_{12}	T_{13}	T_{14}	Absolute Terms Case I	Case II	Case III	Case IV
o'	-1	- .03	- .22				4.47	- 200.50	- 101.00	- 101.00
p'	-1	.00	- .22	.01			3.62	- 202.80	- 106.80	- 106.20
11'	1	.12	4.48	.26	.85		103 .40	539.70	1138.00	145.50
q		.03	.00	.01			- .35	- 2.30	- 5.80	- 5.20
r		.09	4.26	.26	.85		107.87	339.20	1034.00	44.50
q'		1	.03	.24			- 24.92	- 67.70	- 170.50	- 153.00
r'		1	46.25	2.85	9.28		1173.00	3620.00	11250.00	494.00
12'		1	.21	3.91	.12	.62	- 90.65	- 147.20	- 147.80	- 1505.00
s			46.92	2.62	9.28		1197.92	3757.70	11420.50	637.00
t			.18	3.68	.12	.62	- 65.73	- 79.50	22.90	- 1352.00
s'			1	.06	.20		25.93	81.30	247.00	13.77
t'			1	20.70	.70	3.48	- 369.20	- 447.00	128.80	- 7600.00
13'			1	.18	4.36	1.00	65.80	106.70	557.00	2360.00
u				20.64	.50	3.48	- 395.13	- 528.30	- 118.20	- 7613.77
v				.12	4.16	1.00	59.87	19.40	290.00	2346.23
u'				1	.02	.17	- 19.15	- 25.20	- 5.73	- 369.50
v'				1	33.80	8.13	487.00	158.00	2360.00	19080.00
14'				1	1.12	4.23	7.76	- 11.74	13.57	586.50
w					33.78	7.96	506.15	183.60	2365.73	19449.50
x					1.09	4.06	26.91	13.86	19.30	950.00
w'					1	.24	14.98	5.44	70.05	576.80
x'					1	3.72	24.66	12.70	17.70	877.00
y						3.48	9.68	7.27	- 52.35	300.20
y'						1	2.78	2.08	- 15.04	86.05

VALUES OF T

Case	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	T_{13}	T_{14}
I	5.06	- 4.74	3.99	+64.16	-57.0	174.9	-114.7	28.9	- 3.8	-21.0	24.1	-20.0	14.3	2.9
II	8.92	-16.8	1.08	-13.0	-16.2	-38.2	32.9	202.1	194.3	-64.4	81.8	-26.1	4.9	2.1
III	6.85	+13.1	2.03	-19.9	-37.2	- 6.5	127.1	+168.3	84.9	-177.3	252.5	-5.0	73.7	-15.0
IV	8.57	+16.1	1.77	-15.8	-36.4	-24.0	121.9	-181.7	125.4	243.9	-75.8	-397.4	587.0	86.0

Joint	Member	e / l	Case 1 1000 # at point 6		
			T	$2T_{mm} + T_{mn}$	f
1	1-2	.059	1.06	1.14	0.40
	1-3	.045	1.06	1.14	- 0.42
	1-4	.059	16.12	31.30	3.56
2	2-1	.026	- 1.74	1.84	1.00
	2-3	.047	- 68.45	- 192.53	- 10.10
	2-4	.058	- 51.00	- 1[illegible]	- 14.70
3	3-4	.054	3.88	42.60	4.62
	3-5	.038	2.77	[illegible]	- 0.94
	3-6	.058	- 42.34	- 170.14	- 9.35
	3-2	.047	-68 .03	- 190.31	- 10.21
	3-1	.060	- 4.86	- 8.30	- 0.38
	3-1	.059	- 4.86	- 8.30	- 0.47
4	4-2	.026	- 68.16	- 187.38	- 10.40
	4-3	.038	- 94.70	- 212.26	- 11.70
	4-5	.058	-186.86	- [illegible]	- 38.49
	4-1	.058	- 77.16	15.76	1.06
5	5-7	.060	- 17.05	14.38	- 1.72
	5-6	.048	- 62.75	- 8.48	- 0.30
	5-4	.042	- [illegible]	- 225.96	- 27.10
	5-3	.058	34.65	75.25	- [illegible]
6	6-4	.058	174. 7	278.38	31.10
	6-5	.038	111.04	178.38	0.30
	6-7	.048	33.05	73.20	3.11
	6-1	.058	-[illegible]	- 219.26	- 27.00
7	7-6	.044	-111.57	- 201.07	- 41.70
	7-9	.038	- 66.7	- 84.70	- 1.38
	7-8	.038	37.28	77.69	5.44
	7-5	.058	1[illegible] .28	200. 1	- [illegible].0
8	8-10	.058	25.83	76.68	- 0. 0
	8-9	.038	111.78	340.10	24.10
	8-7	.048	24.17	- 61.05	- 0.66
9	9-8	.038	- 3.76	- 171.76	- 11.00
	9-7	.048	80.64	417. 1	[illegible]
	9-6	.038	113.69	340.10	24. 1
	9-10	.048	81.82	161.31	7.94
	9-11	.058	82.96	165.38	12.73
10	10-10	.054	- 81.01	- 28.07	- 3.17
	10-11	.042	24.19	110.30	7.48
	10-9	.048	10.63	08.70	3.31
	10-8	.058	- 19.78	3.47	- 0.10
11	11-9	.058	[illegible]	134.11	13.03
	11-10	.042	44.98	134.09	10.38
	11-12	.038	- 11.35	- [illegible]	- 0.[illegible]
	11-13	.058	- [illegible].45	- 42.37	- 4.98
12	12-11	.038	- 30.00	- 27.12	- 2.14
	12-13	.047	17.[illegible]	72.16	7.38
	12-14	.038	11.66	11.78	0.[illegible]
	12-10	.058	1[illegible].98	4.62	- 0.67
13	13-11	.058	14.[illegible]	0.61	.02
	13-12	.047	[illegible].14	97.04	8.15
	13-14	.058	- 10.22	- 17.[illegible]	- [illegible].0[illegible]
14	14-13	.058	2.7[illegible]	- 4.86	- 0.[illegible]
	14-12	.038	12.58	8.16	0.45
	14-12	.048	12.58	8.10	- 0.82

Joint	Member	$\frac{c}{l}$	Case 11 1000 # at point 9		
			T	$2T_{nm} + T_{mm}$	f
1	1-3	.052	8.92	8.36	0.58
	1-9	.048	8.06	8.85	- 0.72
	1-2	.058	21.98	27.20	2.56
2	2-1	.058	- 16.76	- 11.54	
			- 41.12		- 10.42
11	11-9	.058	41.77	- 1.11	
	11-10	.042	136.48		16.75
	11-14	.088	88.54	71.	8.04
	11-13	.058	- 8.82	- 7.70	- 0.67
12	12-14	.050	- 20.00	- 25.	- 1.41
	12-13	.048	- 80.05	- 82.	
	12-11	.047	41.05	100.26	9.48
	12-10	.088	24.40	7.	0.05
	12-10	.054	26.47	- 11.1	- 0.45
		.058	26.47	- 11.1	0.77
13	13-11	.058	4.20	0.	0.21
	13-12	.047	82.25	180.	10.
	13-14	.088	- 13.66	- 21.10	- 2.07
14	14-13	.058	8.02	- 11.	- 1.01
	14-12	.050	17.54	12.	0.7
	14-12	.048	16.54	14.	- 0.83

TABLE F-2

Joint	Member	$\frac{o}{l}$	Case 11 1000 # at point 9		
			T	$2T_{nm} + T_{mn}$	f
1	1-3	.039	8.92	9.95	0.58
	1-3	.048	5.06	8.95	- 0.72
	1-2	.058	21.98	27.20	2.36
2	2-1	.058	- 10.76	- 11.54	- 1.00
	2-3	.047	- 80.47	- 219.48	- 10.48
	2-4	.058	- 45.08	- 105.15	- 9.00
3	3-5	.034	1.08	15.18	1.24
	3-5	.058	- 1.08	15.18	- 1.32
	3-4	.029	- 42.75	- 127.02	- 8.38
	3-2	.047	- 58.54	- 190.58	- 14.00
	3-1	.039	- 7.89	- 8.86	- 0.40
	3-1	.048	- 7.89	- 8.86	0.49
4	4-2	.058	- 14.99	- 71.06	- 6.18
	4-3	.028	- 38.59	- 110.23	- 4.92
	4-5	.042	- 107.19	- 319.79	- 20.16
	4-6	.058	- 30.29	- 88.81	- 8.60
5	5-7	.034	- 14.18	43.10	3.48
	5-7	.058	- 14.18	43.10	- 1.72
	5-6	.028	- 92.56	- 264.80	- 11.05
	5-4	.042	- 106.41	- 318.01	- 16.70
	5-3	.034	13.02	27.12	2.19
	5-3	.058	13.02	27.12	- 2.36
6	6-4	.058	- 36.22	- 106.75	- 8.30
	6-5	.028	- 94.09	- 270.52	- 11.45
	6-7	.035	- 140.08	- 488.28	- 24.60
	6-8	.058	- 31.53	130.48	10.40
7	7-8	.034	32.93	655.77	53.00
	7-8	.058	32.93	655.77	- 37.00
	7-9	.028	- 26.83	38.13	1.24
	7-6	.035	- 58.72	- 307.52	- 10.30
	7-5	.034	72.46	144.74	11.47
	7-5	.058	72.46	144.74	- 12.70
8	8-10	.034	208.06	582.00	39.70
	8-9	.058	208.06	582.00	- 27.70
	8-6	.035	274.36	774.04	56.20
	8-7	.034	560.71	1418.75	429.00
	8-7	.058	560.71	1418.75	- 108.70
9	9-8	.058	184.04	536.82	39.30
	9-7	.028	89.82	161.06	6.36
	9-6	.035	- 69.72	232.80	13.18
	9-10	.028	- 197.98	- 554.80	- 18.62
	9-11	.058	- 207.15	- 588.88	- 49.00
10	10-12	.034	- 14.00	- 103.22	- 7.56
	10-12	.058	- 84.00	- 102.62	6.42
	10-11	.042	80.20	177.46	11.10
	10-9	.028	0.00	- 181.04	- 6.06
	10-8	.034	- 41.12	144.02	9.80
	10-8	.058	- 41.12	144.02	- 10.60
11	11-9	.058	41.77	- 44.11	- 3.24
	11-10	.042	119.44	347.86	19.78
	11-12	.028	83.84	71.22	3.04
	11-13	.058	- 8.38	- 7.70	- 0.47
12	12-14	.034	- 30.00	- 33.00	- 1.21
	12-10	.046	- 84.00	- 32.62	2.33
	12-13	.047	41.00	134.08	9.48
	12-11	.028	24.80	77.44	3.08
	12-10	.034	30.47	- 31.41	- 0.93
	12-10	.058	30.47	- 31.41	0.70
13	13-11	.058	8.04	7.84	0.61
	13-12	.047	84.48	188.82	10.68
	13-14	.028	- 11.04	- 17.00	- 0.47
14	14-13	.058	2.08	- 11.08	- 1.01
	14-12	.039	18.54	13.00	0.78
	14-12	.048	18.54	13.00	- 0.93

Point	Member	$\frac{c}{I}$	Case 111 1000# at point 11		
			T	2T nm T mn	f
1	1-3	.058	9.45	9.38	0.37
	1-2	.046	7.48	9.60	- 0.46
	1-4	.058	21.01	27.85	1.60
	2-1	.058	- 15.07	- 4.3	- 5.12
	10-9	.058	50.48	50.13	- .01
11	11-9	.058	282.37	284.13	16.40
	11-10	.042	38.16	40.68	0.12
	11-12	.058	- 191.14	- 207.68	- 1.70
	11-13	.058	- 308.60	- 331.24	- 12.90
12	12-14	.058	- 4.96	7.93	0.00
	12-16	.046	- 4.95	9.01	- 0.47
	12-10	.047	141.48	145.65	1.00
	12-13	.058	3.12	3.16	0.03
	12-10	.042	7.8	- 4.81	- 0.37
	12-10	.058	7.8	- 4.81	0.41
13	13-11	.058	7.90	- 4.80	- 0.40
	13-12	.047	141.13	145.00	0.68
	13-14	.042	4.78	- 4.14	- 0.33
14	14-13	.058	- 1.02	- 7.16	- 1.07
	14-16	.058	17.41	20.07	1.13
	14-12	.046	17.41	20.07	- 1.09

Joint	Member	$\frac{a}{l}$	Case 111 1000# at point 11		
			T	2T nm T mn	f
1	1-3	.039	8.26	9.56	0.37
	1-2	.048	.25	9.86	- 0.46
	1-2	.088	21.31	27.25	1.60
2	2-1	.088	- 18.07	- 23.09	- 5.13
	2-3	.047	- 7.78	- 215.15	- 10.10
	2-4	.088	- 42.89	- 168.17	- 3.13
3	3-2	.042	2.03	- 3.97	- 0.32
	3-5	.088	8.03	- 21.77	0.33
	3-4	.086	- 14.10	- 132.09	- 3.71
	3-4	.047	- 5.03	- 173.36	- 9.11
	3-1	.088	- 2.12	- 5.15	- 0.[illegible]
	3-1	.044	- 2.14	- 3.12	0.7
4	4-[illegible]	.0[illegible]	- 1.[illegible]	- [illegible].17	- [illegible].[illegible]
	4-[illegible]	.0[illegible]8	- [illegible].22	- 1[illegible].78	- [illegible].[illegible]
	4-[illegible]	.0[illegible]	- 118.0[illegible]	- [illegible].[illegible]	- 11.10
	4-6	.088	- 87.1[illegible]	- [illegible].	- [illegible].[illegible]
5	5-7	.088	- [illegible].[illegible]	[illegible].1[illegible]	0.10
	7-7	.088	- [illegible].[illegible]	[illegible].15	- [illegible].1
	5-6	.0[illegible]3	- 100.91	- 472.27	- 7.[illegible]
	5-8	.048	- 1[illegible].96	- [illegible].01	- 1[illegible].10
	5-8	.088	- [illegible].03	- 1[illegible].[illegible]	- [illegible].7[illegible]
	5-8	.088	- [illegible].[illegible]	- 1[illegible].[illegible]	[illegible].1
6	6-[illegible]	.0[illegible]	- [illegible].[illegible]0	- [illegible].[illegible]3	- [illegible].[illegible]
	6-[illegible]	.0[illegible]	- [illegible].[illegible]3	- 100.17	- [illegible].[illegible]
	6-7	.088	- 1[illegible].[illegible]2	- [illegible]11.7	- 1[illegible].0
	6-8	.088	- 0.10	[illegible]4.70	[illegible].1[illegible]
7	7-[illegible]	.088	1[illegible].	[illegible]0.[illegible]	1[illegible].10
	7-[illegible]	.0[illegible]3	1[illegible].0[illegible]	[illegible].[illegible]	- 1[illegible].10
	7-8	.048	[illegible]7.[illegible]0	[illegible]3.01	[illegible].[illegible]
	7-[illegible]	.088	[illegible].[illegible]2	- 1[illegible].[illegible]7	- .17
	7-[illegible]	.0[illegible]4	1[illegible].1	[illegible].[illegible]	[illegible].0
	7-[illegible]	.088	1[illegible].[illegible]1	[illegible].[illegible]	- 17.10
8	8-10	.088	- 1[illegible].[illegible]3	- 1[illegible]7.0[illegible]	- [illegible].[illegible]9
	8-10	.0[illegible]	- 1[illegible].[illegible]9	- 1[illegible]7.08	7.0
	8-[illegible]	.088	- [illegible]0[illegible].17	- [illegible]0[illegible].13	- [illegible]1.00
	[illegible]-7	.088	1[illegible].0[illegible]	1[illegible]7.24	.07
	8-7	.048	19.09	1[illegible]7.44	- 0.12
9	9-6	.088	84.90	10[illegible].70	0.36
	9-7	.088	- 40.[illegible]8	- 16.77	- 0.38
	9-8	.088	- 1[illegible].[illegible]E	- [illegible]00.37	- [illegible]1.10
	9-10	.088	- 186.17	- [illegible]1.36	- 1.06
	9-11	.048	- 1[illegible]0.7[illegible]	- [illegible].[illegible]8	- [illegible].[illegible]5
10	10-12	.084	- 177.13	- [illegible]00.00	- 1[illegible].38
	10-12	.088	- 17[illegible].[illegible]	- [illegible]0[illegible].00	17.07
	10-11	.042	[illegible]0.[illegible]	100.70	[illegible].[illegible]
	10-9	.088	197.96	1[illegible].[illegible]	[illegible].46
	10-8	.048	[illegible]0[illegible].[illegible]	[illegible]7.23	[illegible].74
	10-8	.088	[illegible]00.[illegible]	80.[illegible]	- .91
11	11-9	.088	[illegible]3[illegible].17	[illegible]4[illegible].15	1[illegible].0
	11-10	.042	[illegible]0.[illegible]	[illegible].[illegible]	[illegible].15
	11-12	.088	- 1[illegible].14	- [illegible]03.03	- [illegible].70
	11-13	.088	- [illegible]0[illegible].[illegible]	- [illegible]81.[illegible]	- 1[illegible].0
12	12-14	.0[illegible]3	- [illegible].[illegible]	[illegible].11	[illegible].0
	12-13	.048	- [illegible].[illegible]	7.11	- 0.07
	12-10	.047	1[illegible].[illegible]	[illegible]0[illegible].[illegible]	1[illegible].0[illegible]
	12-11	.[illegible]88	[illegible]8.[illegible]	[illegible].16	0.[illegible]
	12-10	.0[illegible]	7.[illegible]	- [illegible].01	- [illegible].[illegible]
	12-10	.0[illegible]	[illegible]7.[illegible]	- [illegible].[illegible]	[illegible].[illegible]
13	13-11	.0[illegible]	7 .70	- [illegible].[illegible]	- [illegible].[illegible]
	13-12	.047	1[illegible].1[illegible]	[illegible].[illegible]	[illegible].[illegible]
	13-[illegible]	.0[illegible]	.[illegible]	- .1[illegible]	- [illegible].[illegible]
14	[illegible]-13	.088	- 1[illegible].0[illegible]	- [illegible].1[illegible]	- 1.7
	[illegible]-12	.088	17.[illegible]	[illegible].7	1.1[illegible]
	[illegible]-12	.048	17.[illegible]	[illegible].[illegible]	- 1.[illegible]

	10-9	.054	- 70.92	-508.54	- 3.01
	10-8	.058	- 74.92	-508.54	5.06
11	11-9	.086	- 78.70	-[illegible]1.67	- [illegible]
	11-10	.042	- 378.38	-508.00	- 1.36
	11-12	.048	- 313.01	-517.30	- 7.84
	11-13	.056	- 21.01	513.16	14.36
12	12-14	.039	- 397.38	-560.81	- 7.02
	12-11	.048	- 377.38	-560.81	5.35
	12-13	.047	- 34.68	-[illegible]7.26	- [illegible]
	12-[illegible]	.0[illegible]	110.[illegible]	- 32.67	- [illegible]
	12-10	.0[illegible]	157.44	70.96	1.93
	12-10	.058	107.44	70.96	- [illegible]
13	13-11	.0[illegible]	[illegible]7.00	1098.09	31.70
	13-[illegible]	.0[illegible]7	60.30	37.12	0.[illegible]
	13-[illegible]	.0[illegible]	- [illegible].70	-1098.78	- [illegible]
14	14-13	.0[illegible]	80.05	- [illegible].20	- 13.1[illegible]
	14-12	.0[illegible]	[illegible].95	470.52	2.10
	14-12	.048	[illegible].95	470.52	- 11.40

Joint	Member	$\frac{e}{I}$	Case 17 1000 # at point 13		
			T	$2T_{mn} + T_{nm}$	f
1	1-3	.039	8.87	9.94	0.19
	1-3	.048	8.87	9.94	- 0.[illegible]
	1-2	.0[illegible]	21.63	27.13	0.79
2	2-1	.0[illegible]	- 16.07	- 10.[illegible]	- 0.[illegible]0
	2-3	.047	- 79.72	-217.41	- [illegible].11
	2-4	.058	- 46.38	-104.58	- [illegible].03
3	3-6	.034	1.77	- 3.70	- 0.10
	3-8	.058	1.77	- 3.70	0.11
	3-4	.028	- 42.06	-128.32	- 1.[illegible]6
	3-2	.047	- 87.86	-198.48	- [illegible].9
	3-1	.039	- 7.20	- [illegible].83	- 0.11
	3-1	.048	- 7.20	- 5.86	0.14
4	4-2	.058	- 18.80	- 75.99	- [illegible].24
	4-3	.028	- 58.40	-131.86	- 1.71
	4-5	.042	- 110.00	-342.17	- 7.26
	4-6	.056	- 38.10	- 90.[illegible]1	- [illegible].66
5	5-7	.034	- [illegible].44	91.87	[illegible].49
	5-7	.058	- 80.44	91.87	- [illegible].[illegible]6
	5-6	.028	- 10[illegible].[illegible]2	-280.10	- [illegible].05
	5-4	.042	- 125.87	-361.04	- [illegible].[illegible]0
	5-3	.034	- 7.24	- 1.[illegible]1	- 0.32
	5-2	.058	- 7.[illegible]	- 1.[illegible]1	0.37
6	6-4	.058	- [illegible].01	- [illegible].[illegible]2	- [illegible].3[illegible]
	6-5	.0[illegible]	- 7[illegible].[illegible]6	- [illegible].10	- [illegible].77
	6-7	.034	- 17[illegible].[illegible]6	-261.75	- [illegible].15
	6-[illegible]	.0[illegible]	- 17.81	70.13	+ [illegible].03
7	7-[illegible]	.034	1[illegible]1.[illegible]2	[illegible]78.81	[illegible].4[illegible]
	7-[illegible]	.[illegible]	181.[illegible]	[illegible]78.[illegible]1	- [illegible].[illegible]0
	7-[illegible]	.0[illegible]	[illegible].7[illegible]	1[illegible].14	[illegible].17
	7-6	.056	0.87	-1[illegible].[illegible]0	- [illegible].07
	7-5	.064	1[illegible].45	[illegible].44	7.[illegible]
	7-[illegible]	.0[illegible]	164.40	[illegible]7.[illegible]	- [illegible].[illegible]6
8	8-10	.0[illegible]	- 1[illegible]1.70	-[illegible]50.[illegible]0	- 10.[illegible]0
	8-10	.056	- 1[illegible]1.70	-[illegible]40.[illegible]8	[illegible]1.[illegible]0
	8-[illegible]	.0[illegible]	- 1[illegible].[illegible]	-[illegible]00.[illegible]8	- [illegible].70
	8-7	.034	[illegible]1.87	1[illegible].[illegible]6	[illegible].0[illegible]
	8-7	.0[illegible]	[illegible]1.87	1[illegible].[illegible]6	- [illegible].[illegible]8
9	9-8	.0[illegible]	1[illegible].[illegible]0	[illegible]2.[illegible]0	[illegible].70
	9-7	.028	181.87	181.87	1.71
	9-[illegible]	.0[illegible]	- 1[illegible].[illegible]0	-[illegible]40.[illegible]0	- 7.[illegible]
	9-10	.028	- 1[illegible].12	-[illegible]10.[illegible]6	- [illegible].[illegible]6
	9-11	.056	- 70.81	-216.40	- [illegible].[illegible]8
10	10-13	.054	- [illegible]41.[illegible]2	-[illegible]30.[illegible]0	- [illegible].[illegible]2
	10-12	.058	- [illegible]04.[illegible]8	-[illegible]78.[illegible]3	[illegible].[illegible]9
	10-11	.042	- [illegible]88.[illegible]8	-[illegible]79.[illegible]3	- 10.[illegible]7
	10-9	.036	- 10[illegible].42	-[illegible]42.[illegible]6	- [illegible].[illegible]0
	10-8	.054	- 70.[illegible]8	-[illegible]06.[illegible]5[illegible]	- [illegible].[illegible]1
	10-8	.058	- 76.[illegible]0	-[illegible]00.[illegible]4	[illegible].[illegible]6
11	11-9	.058	- 7[illegible].[illegible]9	-[illegible]31.[illegible]7	- [illegible].[illegible]4
	11-10	.042	- [illegible]70.[illegible]8	-[illegible]00.00	- 10.[illegible]6
	11-12	.028	- [illegible]17.[illegible]1	-[illegible]17.[illegible]0	- [illegible].[illegible]4
	11-13	.056	- 21.[illegible]1	[illegible]13.[illegible]8	10.[illegible]6
12	12-14	.034	- [illegible]37.[illegible]8	-[illegible]60.[illegible]1	- 7.[illegible]
	12-14	.058	- [illegible]37.[illegible]8	-[illegible]00.[illegible]1	[illegible].[illegible]5
	12-13	.047	- [illegible]5.[illegible]8	-[illegible]17.[illegible]6	- [illegible].[illegible]7
	12-11	.0[illegible]	110.[illegible]	- [illegible]8.[illegible]7	- [illegible].[illegible]0
	12-10	.0[illegible]	1[illegible].[illegible]6	70.[illegible]6	1.[illegible]3
	12-10	.039	1[illegible].44	70.[illegible]6	- [illegible].[illegible]6
13	13-11	.0[illegible]	[illegible]7.00	1[illegible]9.[illegible]2	[illegible]1.70
	13-12	.047	[illegible]0.[illegible]0	[illegible]7.12	[illegible].[illegible]
	13-[illegible]	.0[illegible]	- [illegible].[illegible]0	-[illegible]0[illegible].75	- [illegible].[illegible]0
14	14-12	.0[illegible]	[illegible]0.00	- [illegible]1.[illegible]0	- 1.[illegible]1
	14-13	.0[illegible]	[illegible].[illegible]6	470.[illegible]2	[illegible].[illegible]0
	14-12	.047	[illegible]0.[illegible]5	470.[illegible]2	- 11.[illegible]0

Member		Secondary Stresses for 1000 # at						Axial Stress in tons	Tot. sec. in	
		2	4	6	9	11	15			
Bot. Cord	1-0	- .80	- 1.1	0.10	0.[illegible]	0.7	0.19		- .[illegible]	.
	[illegible]	21.0	1.[illegible]	- 0.[illegible]	- 0.[illegible]	- 0.[illegible]	- 0.[illegible]			
Cont	0-1	7.0	- 0.[illegible]	- 0.[illegible]	- 0.[illegible]	- 0.	- 0.[illegible]	- 1.[illegible]		
	[illegible]	- .[illegible]	0.7	[illegible].7	[illegible]	0. 7	[illegible].[illegible]		- [illegible].1	7.[illegible]
	6-5	- .[illegible]	.[illegible]	.[illegible]	1.[illegible]	- .[illegible]	- [illegible].0			
		.0	- .1	- .[illegible]	- 1.[illegible]	.[illegible]	[illegible].1			
	5-2	.[illegible]	1.05	.00	.1	- .[illegible]	- .[illegible]	- 100.0	- 7.47	7.
1 [illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
[illegible] Diagonal	0-6	.[illegible]	.70	-1 .[illegible]	- [illegible].[illegible]	- [illegible].[illegible]	- 1.71	11..0	- 0.1	7.1
2nd [illegible]	6-8	4.10	- 4.46	- 0.30	-1[illegible].05	- [illegible].65	- [illegible].05		- .77	[illegible].6
[illegible] Diagonal	[illegible]-5	[illegible].00	[illegible].05	[illegible].98	-11.[illegible]	- [illegible].44	- 0.77	106.0	- [illegible].7	6.2
3rd [illegible]	7-9	- .17	- [illegible].60	- 1.38	1.52	[illegible].60	2.17		0.14	0.1
[illegible] Diagonal	9-7	- 1.71	0.58	0.59	[illegible].35	- 0.38	1.71	116.2	12.94	10.9

[illegible] Engineers

[illegible] TECHNOL[illegible]

[illegible] Department

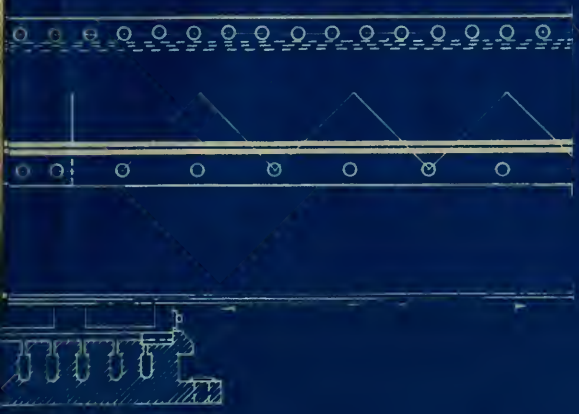
GN[illegible]

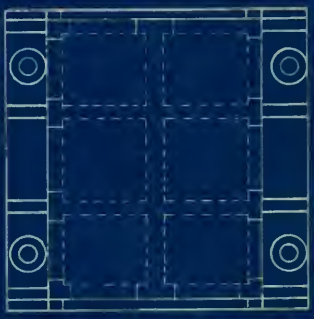
Cale[illegible]

[illegible]

Table 9

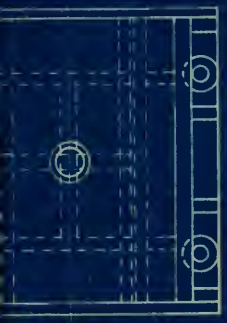
Member		Secondary Stresses for 1000 # at						Maximum Primary tress	Tot. Sec. for Max. Prim.	% Second. of Max. Prim.
		2	4	6	9	11	13			
End Post	1-3 T	- .40	- 1.18	0.40	0.58	0.17	0.19	- 91.6	- 9.04	9.8
	P	11.10	1.44	- 0.49	- 0.72	- 0.46	- 0.24			
	3-1 T	7.07	- 0.30	- 0.38	- 0.40	- 0.32	- 0.11			
	B	- 1.35	0.37	0.47	0.43	0.27	0.14		- 6.61	7.2
Top Chord	3-5 T	- 1.03	2.39	4.69	1.47	- 0.32	- 0.10	- 100.0	- 7.47	7.5
	P	4.06	- 3.01	- 4.04	- 1.38	0.23	0.11			
	5-3 T	4.09	1.35	4.00	1.19	- 0.76	- 0.25			
	B	- 3.56	-17.37	- 3.52	- 1.08	0.81	0.37		- 30.64	30.6
	5-7 T	8.31	- 4.75	1.62	3.48	1.18	0.45	- 103.0	- 30.30	29.3
	B	- 8.36	8.19	- 1.72	- 3.74	- 2.51	- 0.86			
	7-5 T	10.55	6.04	21.72	14.47	10.30	7.89			
	B	-11. 0	- 7.40	-23.30	-15.60	-17.60	- 9.15		- 80.46	74.6
	7-8 T	- 5.09	- .7	- 1.80	13.60	14.60	7.43	- 105.0	- 42.52	40.5
	B	8.35	0.12	20.38	-87.00	-18.60	- 9.00			
	8-7 T	- 7.43	-14.60	- .68	89.00	8.87	5.04			
	B	8.00	16.60	7.12	-105.70	- 9.12	- 5.35		- 85.7	48.1
Bottom Chord	1-2	12.18	1.87	3.66	2.36	1.60	0.79	107.7	28.16	26.5
	2-1	31.30	0.75	1.00	- 1.00	- 5.12	- 2.30		27.96	25.9
	1-4	-30.70	2.60	-14.30	- .00	- 4.19	- 2.00	107.7	- 61.62	57.3
	4-2	-14.66	14.30	-1 .38	- 1.18	- 4.83	- 2.04		- 27.19	25.2
	4-6	4.44	- .30	1.85	- 2.60	- 4.60	- 2.00	113.0	- 26.46	23.0
	6-4	6.18	2.858	31.30	- 2.30	- 2.91	- 1.35		25.87	22.1
	6-9	- 6.78	- 4.36	- 7.00	10.50	3.17	1.05	111.5	- 36.45	32.5
	9-6	- 3.04	3.17	-20.00	23.30	6.36	1.78		24.59	22.1
1st Vertical	3-3	- 0.65	-20.35	-11.10	-10.19	-10. 0	- 5.11	89.8	- 70.37	78.2
	3-8	.98	-17.00	-10. 1	-11.00	- 5.11	- 4.59		- 60.63	67.4
2nd Vertical	4-5	1.36	- 3.15	-30.35	-20.10	-11.30	- 7.68	- 81.2	- 63.04	77.5
	5-4	16.37	- 3.83	- 7.10	-1 .70	-1 .40	- 7.60		- 54.65	67.5
3rd Vertical	6-7	7.72	10.30	3.11	-20.50	-16.00	- 7.15	- 72.9	- 7.50	10.3
	7-6	3.70	1.00	3.20	-1 .00	- 3.17	- .07		7.70	10.4
1st Diagonal	3-4	1.00	- 0.3	- .00	- 3.00	- .71	- 1.00	110.0	- 20.10	17.7
	4-5	.21	.70	-1 .10	- 3.08	- 1.00	- 1.71		- 8.14	7.1
2nd Diagonal	4-8	4.10	- 4.46	- 0.80	-15.05	- 1.65	- 4.05	105.0	- .77	21.6
	8-5	1.00	1.05	0.98	-11.1	- 1.44	- 0.77		- 6.57	6.3
3rd Diagonal	7-8	- .17	- 2.66	- 1.38	1.52	2.66	2.17	118.2	0.14	0.1
	8-7	- 1.71	0.38	0.59	4.35	- 0.38	1.71		12.94	10.9





SHOE — FIXED END

CASTING "D" C.I. 1/2 METAL
HOLES IN UPPER FACE FOR
1/4 BOLTS
HOLES IN LOWER FACE FOR
1 1/2" ANCHOR BOLTS
BEARING R. SAME AS FOR
EXP END
ROLLER SAME AS FOR
EXP END EXCEPT 4 HOLES
FOR 1 1/2 BOLTS IN
CASTING "B"



11/4/20
A. L. Stevens

NY TRUSS

IONS
NG
S 15/16 DIAM

HOLES 9/16 DIAM

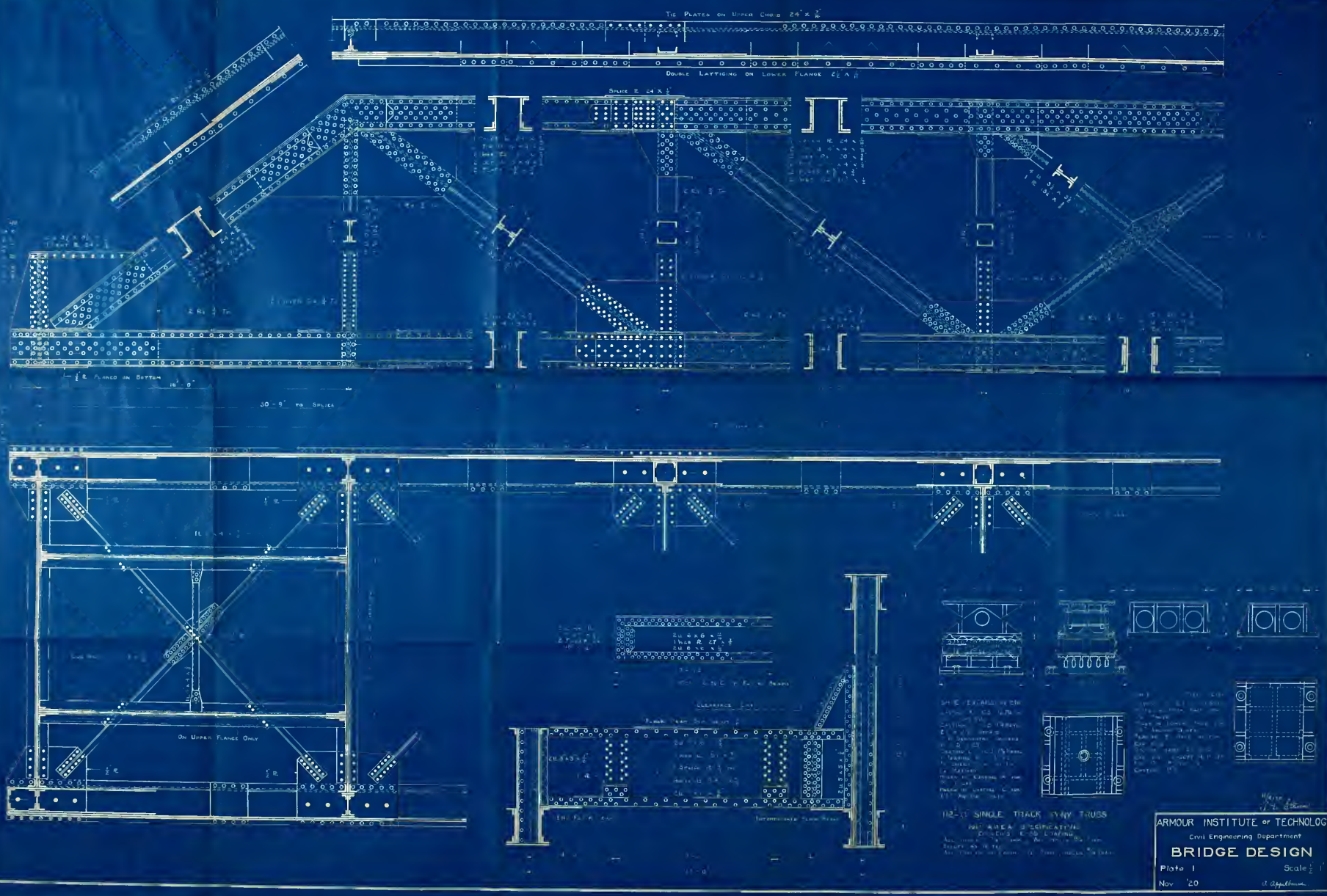
ARMOUR INSTITUTE OF TECHNOL

Civil Engineering Department

BRIDGE DESIGN

Plate 1 Scale 1/2"

Nov '20 A Appelmann


Tie Plates on Upper Chord 24" x 1/2"
Double Lattiging on Lower Flange 2 1/2" x 1/2"
Splice 2 24 x 1/2
1/2" Flared on Bottom
30 - 9" to Splice
On Upper Flange Only
112'-0" SINGLE TRACK HOWE TRUSS
ARMOUR INSTITUTE of TECHNOLOGY
Civil Engineering Department
BRIDGE DESIGN
Plate I
Scale 1/2" = 1'
Nov '20